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***Request for Assistance in***

# Preventing Death from Excessive Exposure to Chlorofluorocarbon 113 (CFC – 113)

*May 1989*

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

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**DHHS (NIOSH) Publication No. 89-109**

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# REQUEST FOR ASSISTANCE IN PREVENTING DEATH FROM EXCESSIVE EXPOSURE TO CHLOROFLUOROCARBON 113 (CFC-113)

## WARNING!

**Working with chlorofluorocarbon 113 (CFC-113) or other chlorofluorocarbons in confined spaces may cause death by cardiac arrhythmia or asphyxiation.**

## SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) requests assistance in reducing the risk of death from cardiac arrhythmia and asphyxiation in workers exposed to 1,1,2-trichloro-1,2,2-trifluoroethane (more commonly known as CFC-113 or by a trade name such as Freon 113®, Genetron 113®, Halocarbon 113®, or Refrigerant 113®) or to other chlorofluorocarbons (CFCs). A number of workers have died recently as a result of exposure to CFC-113 in confined spaces or in areas with insufficient ventilation. These workers were apparently unaware that CFC-113 might generate vapor concentrations sufficient to cause death by cardiac arrhythmia or asphyxiation. NIOSH requests that these recommendations be brought to the attention of workers, supervisors, managers, and owners by the editors of appropriate trade journals, by the members of health and safety organizations, and by all those responsible for the safety and health of workers who use CFC-113 or other CFCs.

**MAY 1989**

## BACKGROUND

Fluorocarbons are halogenated hydrocarbons; fluorocarbons that contain chlorine are called chlorofluorocarbons (CFCs). These colorless, noncombustible liquids are used as refrigerants, propellants, degreasers, fire extinguishants, deicers, and agents for cleaning electronic equipment and preparing frozen tissues for histopathology.

Of the more than 36 commercially available fluorocarbons, approximately 12 are produced and used in significant quantities. One of these, 1,1,2-trichloro-1,2,2-trifluoroethane,* is more commonly known as CFC-113 or by such trade names as Freon 113®, Genetron 113®, Halocarbon 113®, or Refrigerant 113®. The National Occupational Hazard Survey (NOHS) estimates that 300,000 workers are potentially exposed to CFC-113 [NIOSH 1977].

Because of its high vapor pressure (285 millimeters of mercury) at room temperature, CFC-113 can produce high ambient concentrations of vapor during normal use of the liquid. Uncontrolled use therefore poses a significant hazard and can result in lethal workplace concentrations, particularly in confined spaces.†

This hazard is clearly demonstrated by the reports of worker deaths presented in this *Alert*. All of the deaths resulted from exposures to CFC-113 and subsequent cardiac arrhythmia or asphyxiation. The hazard is especially significant because of the extensive use of CFC-113 for degreasing, cleaning, drying, and refrigeration.

## TOXIC EFFECTS

For more than a decade, published reports have indicated that fluorocarbons can induce respiratory depression, bronchoconstriction, and death in exposed workers and individuals who use them for psychophysiological effects [Bass 1970; Reinhardt et al. 1971; Garriott and Petty 1980; EPA 1983; May and Blotzer 1984].

A study with human volunteers who inhaled CFC-113 for 1.25 to 2.75 hours (hr) indicated that 2,500 parts of CFC-113 per million parts of air (2, 500 ppm) may be the threshold for impairment of psychomotor functions such as manual dexterity, vigilance, and ability to concentrate; such impairment disappeared within 15 minutes (min) after exposure ceased [Stopps and McLaughlin 1967].

The lethal airborne concentration of CFC-113 for humans may be similar to that for animals. The mean lethal concentration ($LC_{50}$) is the concentration at which 50% of inhalation-exposed animals die during a specific time period. In rats, the 4-hr $LC_{50}$ for CFC-113 ranges from 52,000 to 68,000 ppm [ACGIH 1986].

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*Chemical Abstract Service (CAS) Number 76-13-1 and National Institute for Occupational Safety and Health (NIOSH) Registry of Toxic Effects of Chemical Substances (RTECS) Accession Number KJ4000000 [NIOSH 1987e].

†NIOSH has previously defined a confined space as having the following characteristics: (1) limited openings for entry and exit, (2) unfavorable natural ventilation, and (3) continuous worker occupancy [NIOSH 1979, 1987a].

Chemically induced cardiac (ventricular) arrhythmia, fibrillation, and death have been confirmed in experimental monkeys, dogs, and mice exposed by inhalation to CFC-113 and a number of other CFCs. These responses were ascribed to epinephrine hypersensitivity [Clark and Tinston 1973; Aviado 1975; Reinhardt et al. 1973]. Reinhardt et al. [1973] demonstrated that conscious dogs do not exhibit cardiac arrhythmias when exposed to CFC-113 alone or to epinephrine administered alone intravenously (IV). However, when a 5-min CFC-113 exposure at 10,000 ppm was followed by an IV injection of epinephrine, cardiotoxicity resulted in three of four treated dogs. Two dogs developed severe arrhythmias, and the third experienced fibrillation and cardiac arrest. These effects were not induced by the same IV dose of epinephrine following CFC-113 exposures below 5,000 ppm.

## REGULATORY STATUS

Both the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) [29 CFR* 1910.1000 (1988)] and the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV®)[ACGIH 1988] for CFC-113 are 1,000 ppm as a time-weighted average (TWA) over an 8-hr workshift with a 15-min short-term exposure limit (STEL) of 1,250 ppm. The TLV is based on "providing a margin of safety for systemic effects and an adequate margin against cardiac sensitization" [ACGIH 1986]. Although NIOSH has no recommended exposure limit (REL) for CFC-113, the Institute has determined that 4,500 ppm is immediately dangerous to life and health (IDLH) [NIOSH 1985]. Furthermore, NIOSH considers this substance to have poor warning properties because it is nearly odorless and its irritant effects are only slight and transient at concentrations near the PEL [NIOSH/OSHA 1981].

## FOUR CASE REPORTS OF FATAL INCIDENTS

The following four reports describe 12 fatalities resulting from occupational exposure to CFC-113 in confined spaces; they are typical of situations in which CFC-113 can cause death. All of the deaths described here were attributed to cardiac arrhythmia or asphyxiation or both.

### Case No. 1 (one death from cardiac arrhythmia)

The Michigan Department of Public Health [1983] reported that on November 14, 1983, a military tank was brought to a maintenance shop for repairs. Before repairing it, workers cleaned the tank's interior by flushing with 15 gallons (gal) of CFC-113. The tank was then parked outside on an inclined ramp for draining of the CFC-113. Because mechanical ventilation was not used to speed the vaporization process, some CFC-113 remained in the tank. This method was commonly used to clean the interior of these military vehicles.

On the evening of the flushing operation, a worker drove the tank back into the repair shop. The driver later indicated that he was seriously affected (details not reported) by the CFC-113 vapor in the tank, but he made no formal complaint of the incident.

*Code of Federal Regulations. See CFR in references.

The next day, another worker climbed into the tank and started the engine. He did not assess the air quality and was not wearing a respirator or protective clothing. Starting the engine also activated an interior ventilation system that moved residual CFC-113 vapor into the driver's breathing zone. Shortly thereafter, he was seriously affected by the vapor. He alerted his coworkers and then lost consciousness. Workers who attempted to revive him and remove him from the vehicle reported that they almost passed out from the CFC-113-contaminated air. The worker never regained consciousness and was pronounced dead after being taken to a hospital. Upon autopsy, the medical examiner identified the cause of death as cardiac arrhythmia resulting from inhalation of CFC-113 vapor.

Although the victim's exposure time was brief (approximately 1 min), the exposure concentration was estimated to be very high. This estimate was substantiated 24 hr after exposure, when the Michigan Department of Public Health measured airborne CFC-113 concentrations inside the vehicle. They were as high as 7,600 ppm--well above the NIOSH IDLH concentration of 4,500 ppm for CFC-113 [NIOSH 1985].

### Case No. 2 (two incidents, two deaths from cardiac arrhythmia)

May and Blotzer [1984] reported two separate incidents of deaths resulting from cardiac arrhythmia after workers were exposed to CFC-113 vapor in confined spaces. In one case, a worker who was not wearing a respirator or protective clothing was exposed to CFC-113 while cleaning the inside of a small degreasing tank. The worker was found collapsed in the tank and was taken to a local hospital where he was pronounced dead as a result of cardiac arrhythmia.

In the second case, a worker who was also not wearing protective equipment was exposed while using CFC-113 to test for leaks in compressed air lines in a small room aboard a marine vessel. He was overcome and later died from cardiac arrhythmia. Two other workers were also overcome while trying to rescue him; both recovered.

### Case No. 3 (six incidents, eight deaths)

The U.S. Navy [1985] reported six incidents involving eight deaths from inhalation of CFC-113. All of these deaths involved exposure to the vapor in either a confined space such as a storage tank or in a small room such as an engine compartment or air conditioning facility. Of the eight deaths, seven were due to asphyxiation and one to cardiac arrhythmia. One additional death was reported from an unknown cause, but it was probably related to CFC-113 exposure. The ages of the victims ranged from 19 to 26 years.

### Case No. 4 (one death from asphyxiation)

This case was investigated by staff from the NIOSH Division of Safety Research [NIOSH 1986]. Four men at a chemical plant were assigned to clean a vapor/ultrasonic degreasing tank where metal parts were cleaned with CFC-113. The tank (6 feet [ft] 4 inches [in.] high, 8 ft long, and 4 ft wide) was located in a small building used exclusively for cleaning metal parts.

Without entering the tank, three workers, who were unfamiliar with the company's written instructions for cleaning the tank, drained all but approximately 1 gal of the CFC-113 from the degreaser and then went to lunch. When they returned, a fourth worker, who was familiar with the cleaning process, joined the other three. He and one of the three workers donned half-mask respirators with organic vapor cartridges and paint-spray prefilters, climbed into the tank, and began cleaning the bottom. Soon after entering, both workers had breathing problems and climbed out of the tank. The worker who was familiar with the cleaning process then collapsed and was transported to a local hospital, where he was pronounced dead as a result of asphyxiation and pulmonary edema. The other worker did not experience any long-term ill effects. Although air was not monitored, estimates of CFC-113 concentrations were as high as 300,000 ppm, which greatly exceeds the NIOSH IDLH of 4,500 ppm.

## CONCLUSIONS

Few data exist to describe the effects of CFC-113 or other CFCs on humans. However, data from animal studies generally demonstrate that CFC-113 concentrations of approximately 50,000 ppm are lethal to rats [ACGIH 1986]. Death from cardiotoxicity was observed among dogs exposed at 10,000 ppm CFC-113 and then injected IV with epinephrine [Reinhardt et al. 1973]. These data and the deaths of the workers described in this report demonstrate that exposure to CFC-113 is hazardous and can cause death by cardiac arrhythmia and asphyxiation. The human health effects of CFC-113 are summarized in Table 1.

**Table 1. --Human health effects related to various concentrations of CFC-113**

| Concentration (ppm) | Health effect |
|---|---|
| 1,000 | No adverse health effects (OSHA PEL) |
| 2,500 | Impairs ability to perform simple tasks; induces mild lethargy and loss of ability to concentrate |
| 4,500* | Considered IDLH |
| 7,600 (measured 24 hr after exposure) | Death from cardiac arrhythmia (Case No.1) |
| 300,000 (estimated) | Death from asphyxiation and pulmonary edema (Case No. 2) |

*The IDLH concentration can be reached in a confined, unventilated space by evaporating as little as 21 ounces (about 1.5 pints) of CFC-113 in an enclosed, 1,000-cubic-ft area (10 by 10 by 10 ft) [AIHA 1982].

Several factors that contribute to the hazards of exposure to CFC-113 and that are applicable to other CFCs are as follows:

- Use in confined spaces
- High vapor pressure, which results in hazardous vapor concentrations, particularly in confined spaces
- Poor odor warning properties and absence of irritation
- Relatively low toxicity up to approximately 2,500 ppm, which leads workers to believe that the chemical is inherently safe

These factors may work together to create situations in which workers may be exposed to CFC-113 or other CFCs at concentrations sufficient to cause death by cardiac arrhythmia or asphyxiation.

## RECOMMENDATIONS

NIOSH recommends the following measures for controlling exposures to CFC-113 and other CFCs:

### 1. Hazard Awareness

Workers should be warned about the hazards of exposure to CFC-113--particularly that exposure can cause death by cardiac arrhythmia or asphyxiation. Furthermore, workers should be warned that CFC-113 is especially hazardous when used in confined spaces or in poorly ventilated areas.

### 2. Training

Training should include information about

- the hazards of using CFC-113, especially in confined spaces,
- the use of appropriate protective gear, including respiratory protection, and
- all other aspects of working safely with CFC-113.

### 3. Engineering Controls

Consider substitution of a less toxic chemical than CFC-113 for operations conducted in confined spaces or for any situation where there is potential for exposure at concentrations above the OSHA PEL of 1,000 ppm. If substitution is not possible, use other forms of engineering controls such as ventilation or isolation to reduce exposure to CFC-113.

### 4. Hazards in Confined Spaces

Because the hazards associated with CFC-113 increase dramatically when it is used in confined spaces, workers should follow all recommendations identified in the NIOSH documents entitled *Criteria for a Recommended Standard....Working in Confined Spaces* [NIOSH 1979] and *A Guide to Safety in Confined Spaces* [NIOSH 1987a].

## 5. Medical Considerations

All persons with significant exposure to CFC-113 should be examined by a physician to identify medical conditions that might increase the risk associated with this exposure (e.g., cardiovascular disease) [NIOSH/OSHA 1981]. Workers taking medications containing catecholamines should also be advised by the examining physician that they may be at increased risk and should avoid excessive exposure to CFC-113. Medications that may be of concern include epinephrine, norepinephrine, and dopamine, as well as isoproteranol and other sympathomimetic agents commonly used by asthmatics [Reinhardt et al. 1973; Balazs et al. 1986]. Emergency medical service (EMS) personnel should also be aware of the potential problems with using these medications in patients after excessive exposure to CFC-113 or other CFCs.

## 6. Personal Protective Equipment

### a. Respiratory Protection

The following recommendations for respiratory protection should be implemented for all exposures to CFC-113, particularly those that occur in confined spaces or in areas with insufficient ventilation.

Although engineering controls and work practices should be used to minimize exposure to CFC-113, certain situations may require the use of respirators--for example, some confined-space operations, emergencies, and some setting-up or repair operations. As demonstrated in Case No. 2, the use of air-purifying, half-mask respirators was not sufficient to protect against high concentrations of CFC-113. NIOSH recommends that supplied-air respirators (SARs) or self-contained breathing apparatus (SCBAs) be used for CFC-113 because of its poor warning properties [NIOSH/OSHA 1981]. Table 2 lists the types of respiratory protection recommended for CFC-113 under various conditions. For additional information on the selection and use of respirators, refer to the *NIOSH Respirator Decision Logic* [NIOSH 1987d] and the *NIOSH Guide to Industrial Respiratory Protection* [NIOSH 1987c]. Respirators should be approved by NIOSH and the Mine Safety and Health Administration (MSHA) [NIOSH 1987b].

### b. Chemical Protective Clothing

Although skin absorption of CFC-113 is not a recognized route of exposure contributing to systemic toxicity or cardiovascular effects, repeated contact with the chemical can produce irritation and drying of the skin and irritation and tearing of the eye. In addition, contact of skin or eye tissues with liquid CFC-113 may result in chilling or freezing from rapid evaporation of the liquid.

To minimize skin contact and absorption, workers using CFC-113 should wear appropriate chemical protective clothing (CPC) such as gloves and aprons. CPC made from neoprene and nitrile rubber should provide adequate protection for at least 1 hr [Schwope et al. 1985]. Note, however, that the quality of gloves may vary significantly among glove producers [Mickelsen and Hall 1987]. Product-specific chemical permeation data should therefore be obtained from the glove manufacturer. If CFC-113 gets on the skin, promptly wash the contaminated area with soap or a mild detergent and water. Splash-proof safety goggles should be worn if there is any possibility that liquid CFC-113 will contact the eyes. If contact does occur, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally; get medical attention as soon as possible.

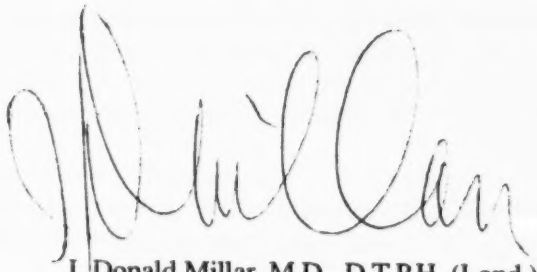
**Table 2. --Respiratory protection recommended for CFC-113**

| Condition | Minimum respiratory protection |
|---|---|
| Concentration less than 4,500 ppm | Any SAR,* or<br><br>Any SCBA† |
| Concentration greater than 4,500 ppm, or planned or emergency entry into unknown concentrations | Any SAR equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary SCBA operated in a pressure-demand or other positive-pressure mode, or<br><br>Any SCBA equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode |
| Firefighting | Any SCBA equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode |
| Escape only§ | Any air-purifying, full-facepiece canister respirator providing protection against CFC-113 and equipped with an end-of service-life indicator (ESLI), or<br><br>Any SCBA equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode |

*Supplied-air respirator.
†Self-contained breathing apparatus.
§If the atmosphere is oxygen-deficient (less than 19.5% oxygen), use SCBA option only.

NIOSH requests that these recommendations be brought to the attention of workers, supervisors, managers, and owners by the editors of appropriate trade journals, by the members of health and safety organizations, and by all those responsible for the safety and health of workers who use CFC-113 or other CFCs. Requests for additional information or questions related to this announcement should be directed to Dr. Richard Niemeier, Acting Director, Division of Standards Development and Technology Transfer, NIOSH, 4676 Columbia Parkway, Cincinnati, Ohio 45226-1998; telephone (513) 533-8302.

We greatly appreciate your assistance.



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**DHHS (NIOSH) Publication No. 89-109**

☆U. S. GOVERNMENT PRINTING OFFICE: 1989/648-164/81533